WATER-SUPPLIES OF SOUTHEASTERN KANSAS.

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IN choosing the subject for the address this evening, I have taken occasion to glance over the subjects of the papers that have been used in similar addresses since the by-law was passed requiring an address by the retiring president.

These subjects have been of various natures; some dealing with the relation of science to everyday life, or to the schools, or to the nineteenth century, or to the state. Others are of a more special scientific nature, dealing with a chemical, an astronomical, a geological or a biological subject. Still others deal with scientific problems, the solution of which should be undertaken by the state. I would place mine this evening in the last class.

I might have chosen as a title for my address one analogous to that of President Brown, delivered in 1884. His title was, "Is a Geological Survey of the State a Necessity?" My title might be, "Is a Chemical Survey of the State a Necessity?" or, to speak boldly, "A Chemical Survey of the State is a Necessity."

The chemical work in the state has been limited. The work done, though very limited, has been very valuable in respect to the analyses of coal, gypsum, and mineral waters. Also, at the Experiment Station of the State Agricultural College at Manhattan, systematic work is being done in the examination of farm products and fertilizers. While I know that the state should provide a chemical survey of its minerals, including oil, gas, coal, salt, gypsum, lead and zinc ores, and should make provision for the chemical analysis to prevent food adulteration, I have chosen to confine myself in this address to the water-supplies of the state.

Owing to the size of the state, I have chosen to speak in detail of only the southeastern section; therefore my title, which appears on the program, "Water-supplies of Southeastern Kansas." I trust that, by a description of the conditions existing in that small section of the state, I may show you that a chemical survey of the water-supplies of the entire state will be of advantage, nay, will be or even is a necessity.

I will deal only with the watersheds of the Marais des Cygnes, Neosho and Verdigris rivers, because I have made some systematic examination of the water of these three rivers. These rivers drain all or part of twenty-two counties, having an area of 14,000 square miles,

and a population of about 400,000. In area these counties equal in size the combined areas of the states of New Hampshire and Connecticut, and they were as thickly populated as either New Hampshire or Vermont at the time of the last census. Moreover the population has greatly increased since the last census, owing to the rapid development of the oil- and gas-fields.

The gas-fields had been drawn upon for several years for city gas supplies, and a small oil refinery was operated at Neodesha prior to 1901. It is from that date that the operations began to assume the colossal dimensions that in a few years will make the Kansas-Indian Territory-Oklahoma field the greatest in the United States, and probably the greatest in the world. The output of oil has increased one hundred fold in the last four years—from 200 barrels per day in 1900 to 20,000 barrels per day in 1904. The handling of this oil means a large increase in population, and, in addition, brick plants, cement works, zinc smelters and glass factories are using the gas and bringing thousands of people into this section.

It is necessary to provide an abundant supply of pure water for this increased and increasing population, and it is necessary to take proper care of the sewage from these enlarged and enlarging cities. The individual city will have a tendency to look out for itself, to the possible, even probable, detriment of neighboring cities. For example, a city may obtain its water-supply from one of these rivers and dispose of its sewage into the same river further down. This, however, cannot be done without detriment to other cities further down the stream. At certain seasons of the year the rivers in this southeastern section are so decreased in volume that they will not afford sufficient dilution to purify the organic matter which exists in these enlarged and enlarging cities. One such case suffices to show that the state should have a general oversight of the water-supplies and sewage systems throughout the state of Kansas.

In order to learn definitely the source of the water supplied to the cities of this southeastern section, I have addressed letters to the mayors of said cities. According to the United States Gazetteer for Kansas (1898), there are 119 cities and villages in this section of the state—thirty-five in the Marais des Cygnes watershed, fifty-six in the Neosho, and twenty-eight in the Verdigris. I have received replies from seventy-five of the cities, and find that twenty-seven have already a public water-supply, nineteen of which obtain their supply in whole or in part from these rivers. Only thirteen have public sewers, and, as far as my knowledge extends, these empty into these rivers. Thirty-nine from which replies were received obtain their supplies from wells and cisterns. A few obtain their supplies from springs and one from a lake.

PLATE V.—Kansas Academy of Science Museum, 1905 (looking west)—Capitol Building, Topeka.

We thus see by an examination of the reports that the source of the water used by these cities is either cisterns, wells, or rivers.

You may think it unnecessary for me to spend time in telling you things you already know in regard to the value of a good general supply of a good, pure water for cities and towns, but a review of the reasons for the necessity of an abundant supply of pure water may help to show you the necessity for a chemical survey of the water-supplies. It will also introduce what I have to say in regard to the advantages and disadvantages of the various sources of water-supply available in southeastern Kansas.

A good supply of pure water is of value to the household, to the manufactory, and to general public use. Most important of these three is the service to the household. Here, first of all, pure drinking-water is needed, on account of its relation to the health of the individual and therefore to the community. It is an established fact that many disease germs are carried by water, for such diseases as cholera and typhoid fever have been traced directly to the water-supply. A change in the source of the water-supply, by which a purer water is obtained, reduces the possibility of such diseases. This was shown in the city of Chicago, where the water intake was extended to four miles into the lake. The average death-rate from typhoid fever was reduced from 8.0 per 10,000 for seven years prior to 1892, when the extension was made, to 3.4 per 10,000 for the seven years following, a reduction of more than 50 per cent.

Again, the introduction of purification systems have reduced the death-rate from these germ diseases. As an example, the average annual death rate per 100,000 from typhoid fever in Zurich was reduced from 73.6 to 9.0 after the introduction of new filters. This is a reduction of more than 800 per cent.

A plentiful supply of water as soft as possible is needed in the household for bathing and for laundry purposes. Parkes in his book, "Hygiene and Public Health," says that the city of Glasgow saves annually $180,000 in the amount of soap used since the introduction of the soft Loch Katrine water. The most economical method for the proper disposal of household waste is by dilution with water, and the carrying of the same into a sewage system. For this household use we see that an abundant supply is needed.

Many branches of industry require large amounts of water, and these necessarily must choose their location on account of an abundant supply. Oil refineries, starch factories, chemical works, need large amounts of water, and in some cases a water of a high degree of purity. Every user of power depending on steam must have a good water for the boilers. Here the soft water—that is, a water free from scale-forming materials—has the preference. The saving in fuel con-

sumption and in the durability of boilers will compare with the saving of soap in the household. Therefore, the location of many factories depends not only on the quantity of the water-supply, but also on the quality.

The most important general public use is for fire protection. For this purpose the primary need is an abundant supply. An abundant water-supply lowers the rates of insurance, and it is far better to pay a small tax for fire protection of this kind than to pay a heavy insurance rate.

Then, the water serves to sprinkle streets, to water lawns, to flush sewers, to give drinking and ornamental fountains. These uses add to the comfort of the people and to the attractiveness of a city, increasing the value of property.

With the cheap power available throughout the oil and gas region, an abundant supply can be easily obtained for general public use, and with care as to the quality, this supply will also serve the manufacturer and the household. It must be remembered that the first need is a pure water for drinking; the second, a water as soft as possible for laundry and boiler use; third, an abundant supply for flushing sewers and for fire protection.

The water available for water-supplies in southeastern Kansas may be classed as rain-water, ground-water, and surface-water. Let us consider each with reference to its advantages and disadvantages when applied to the various needs of the community. Rain-water—and by that I mean water collected on roofs and stored in cisterns, commonly termed cistern water—is seldom obtained pure. It washes from the air the dust that is blown from the highways and the gases that are present from the fumes of the chimneys of houses, factories, and furnaces. It washes from the collecting surface the dust, excrement of birds, and decayed leaves.

The cistern into which this water flows generally contains a filter of soft brick, which is supposed to remove all impurities. This filter will be effective at first, but it soon becomes saturated with the foul matter removed from the water and is then a breeding-place for bacteria, and serves to inoculate the water which passes through.

The rain which falls after the air is washed and the collecting surface is cleansed is quite pure. If care be taken to save only this part of the rain-water, water of a satisfactory quality for any purpose will be obtained. Most cisterns have an arrangement by which the first part of a shower can be diverted; but usually no attention is paid to it, and as Professor Palmer, who conducted the "Chemical Survey of the Waters of Illinois," has said, "It soon reaches a state of noxious desuetude."

It contains no mineral salts, and hence is soft, and is, therefore,

good for laundry use and for boilers. Owing to the necessity for large storage to tide over a dry season, it is not suited to general public use, although cisterns are often built in small towns for fire protection.

From what has been said, one would conclude that, as a rule, cistern water is not well suited for drinking, and that its value for drinking or for fire protection is inversely proportional to the size of the city or town in which it is collected.

The second available source of water-supply in southeastern Kansas, namely, ground-waters, includes water of deep and shallow wells and water from springs. Deep wells are not possible in the greater portion of southeastern Kansas, as oil and salt water are found. The majority of the people rely on shallow wells for their drinking-water. In the country, with due care to prevent contamination, these are very satisfactory. They are liable to receive seepage and drainage from the surface down, and, therefore, in cities and villages are to be avoided. One may be careful of his own house, drainage, and sewage, but one cannot control the house drainage of a careless neighbor. That ground-waters are affected by the presence of people is shown by investigations in Massachusetts. These show that 100 persons to the square mile increase the normal chlorine of the district by 0.5 parts per million.

The users of wells rely on the powers of the earth as a filter. The earth is a good filter, but must not be used beyond its limits. It has been shown that sewage thrown continuously on the ground in the same place will very quickly saturate the earth with impurities, and then contamination will be carried long distances, especially if the seepage finds an underground passage. A case is on record of typhoid germs being carried a mile underground, then contaminating a spring, causing a serious outbreak of the fever. (Lausanne, Switzerland).

Intermittent additions of sewage to the same spot, allowing time for the air to come in contact with the earth, will be satisfactorily filtered, for the earth allows the growth of bacteria which, in the presence of air, destroy the organic matter and the harmful germs.

Wells that have been used a long time are usually considered safe. Again and again I have been told that a well under examination has been used for years, causing no illnesses. These wells sometimes contain diluted sewage from healthy sources as a result of small seepage. These sources may at any time become contaminated and dangerous. Diluted sewage containing no pathogenic germs may be drunk with impunity. Still more safely can a perfectly treated sewage be taken internally. When people are offered such sewage, though they are told that it is perfectly germ free, yet they hesitate to drink.

These same people will not hesitate to drink well-water that they know nothing about, which may contain diluted untreated sewage.

A soft well-water from a source free from contamination is excellent for any purpose. Wells in this section, on account of the limestone, would usually furnish a hard water that requires a large amount of soap and forms a boiler scale, making it an undesirable water for the laundry or for manufacturing purposes. For general public use, of course, the only requirement would be a high rate of flow, to furnish an abundant supply.

The third source of water-supply to be considered—surface-water—may be described as a combination of rain-water and ground-water. This water is usually from lakes, rivers, or impounding reservoirs. In southeastern Kansas there are no large lakes; hence the streams are the only source of surface-water to be considered.

To be entirely pure, a surface-water should be collected from an uninhabited region. New York city obtains its water-supply from surface-water. Considerable areas have been depopulated, farms have been condemned, and even whole villages have been removed from the watersheds of its reservoirs. It has become a great problem to furnish a sufficient supply of pure water, and at present they are contemplating still further operations of the same kind.

In southeastern Kansas the rivers necessarily receive the drainage, not only from houses but from streets and barn-yards. The organic matter in this drainage will be removed and destroyed, if there is sufficient dilution and if there is a sufficient lapse of time between the contamination and the use of the water. The greatest danger lies in contamination by disease germs. Some are nearly always present in the sewage of a city.

An illustration of the effect of such contamination is the typhoid epidemic that raged in the Hudson valley in 1890–'91. Prof. William P. Mason, of Rensselaer Polytechnic Institute (Water-supply, p. 33), investigated in person, and describes it somewhat as follows: "The epidemic began at Schenectady in July, 1890. The drainage of Schenectady passes into the Mohawk river. Typhoid fever broke out at Cohoes, farther down the river, in October, and at West Troy in November. These cities obtain their water-supply from the Mohawk, and return their sewage into the Mohawk and the Hudson. Typhoid fever broke out at Albany, six miles below West Troy, in December. Albany's water-supply is obtained from the Hudson, opposite the city. There was practically no typhoid in Waterford and Lansingburgh, cities connected to Cohoes by bridges, but cities that obtain their water-supply from the Hudson above the Mohawk junction and from the hills, respectively. There was also no fever in Troy proper, supplied with water from the Hudson above the Mo-

hawk junction. Albany, at least, has since introduced a filtration plant."

Not only can a river be infected by sewage from a city but it may be infected by a single individual. The fecal discharges of a person suffering from typhoid fever thrown upon the ground have been known in well-authenticated cases to have been washed by rain or melting snow into a stream which serves as a water-supply. The outcome was a serious epidemic, with loss of life.

Cities are being built up so near each other on these Kansas rivers that it seems advisable to suggest and even to demand that no untreated sewage be allowed to flow into these streams, and that no unfiltered water be allowed to enter the service-pipes of any water system.

Special caution is needed in this section, for an abundance of water can only be obtained from these rivers. Think of the list of larger cities on the Neosho all taking their water-supply from this river and emptying their sewage directly or indirectly into it—Emporia, Burlington, Iola, Humboldt, Chanute, Erie, Oswego. The same statement may be made of the cities on the Verdigris, though a smaller list on a smaller stream—Fredonia, Neodesha, Independence, Coffeyville.

A chemical examination of the water of these three river systems was carried on in the laboratory for water analysis of the University of Kansas during 1903–'04. The expenses of collection were defrayed by the division of hydro-economics of the United States Geological Survey. The work was under my direction, and I was ably assisted by Mr. A. W. Sellards, K. S. U., in 1903, and by Mr. P. C. Jeans, K. S. U., in 1904. Collections of water were made principally during the college year at Ottawa, La Cygne, Emporia, Burlington, Chanute, Oswego, Benedict, Independence, and Fredonia. Turbidity readings have been made since July, 1904, at Ottawa, Emporia, Oswego, and Fall River. Results are to be published in full. The most important conclusion to be drawn is that these rivers, on account of the organic matter and turbidity, do not furnish a water that can be used as a household supply without treatment. Investigations should be undertaken to find the best method of treatment for rendering it serviceable, whether by filtration or by settling-basins, with or without a coagulant. Preliminary tests, when a treating plant is to be established, are almost a necessity, and have been shown to be of great value at Louisville and Cincinnati, where the Ohio river was tested.

As a rule, a turbid river-water contains organic matter and bacteria, but sometimes a turbid well-water may be practically germ free, when the water of a deep well contains a large amount of ferrous iron. Such water may be clear and bright when first drawn, but become turbid on standing. Most people do not like to drink a turbid

water, and will drink instead any clear well-water, regardless of its source.

The waters of these rivers must be treated to render them clear and germ free for household use. And it is possible to treat them in such a way as to make them soft for laundry and manufacturing purposes. The question that occurs to many is, What is the use? or, in other words, Does it pay?

As an example of the use of filtration to obtain a germ-free water, I will mention the experience of the adjoining cities of Hamburg and Altona, in Germany, during the cholera epidemic of 1892. Hamburg used unfiltered Elbe water, while Altona used filtered Elbe water after it had received the sewage of over 800,000 people of Hamburg. The cases rate in Hamburg was 263 per 10,000 inhabitants, while in Altona it was only 38.1, and most of these cases had their origin in Hamburg. One part of Hamburg, supplied by water from Altona, did not have a single case, though surrounded by the disease.

As an example of the value of water treatment to soften it, I will refer to the work of the Santa Fe railroad in analyzing and treating waters throughout its system, from Chicago to California. In the *Journal of Locomotive Firemen*, Mr. Powers, the chief chemist for the Santa Fe, tells of the work done, and I take the liberty of reviewing his article. In 1902 the Santa Fe began the treatment to soften waters by means of soda ash and lime. In September, 1904, there were sixty-six plants in operation, capable of treating from 50,000 to 300,000 gallons of water per day, at a cost of from one cent to eight cents per 1000 gallons. Cost depends on the quality of the water. It is calculated that the treatment removes four and one-half tons of incrustants daily from 3,570,000 gallons of water used. From the only plant thus far erected in southeastern Kansas, at Neosho Rapids, 150 pounds of incrustants are removed from a daily consumption of 50,000 gallons. The results are highly satisfactory, and the life of flues and fire-boxes has been more than doubled.

The Kansas cities as individual cities are not large enough to undertake the necessary examinations advantageously. It is a task for the state. Other states and some large cities have established chemical surveys of their water-supplies. Considerable surveys of streams, watersheds and other possible sources of city supplies have been thoroughly examined. Several states have undertaken such work, sometimes from a chemical standpoint only, and in other cases bacteriological examinations have been included.

The most expensive work has been done by Massachusetts, carried on under the auspices of the State Board of Health. Their work was begun in 1887, and made possible by an act of the legislature, which is quoted elsewhere. Connecticut has made similar examinations.

New York city has carefully examined its watershed, and has recently extended its examinations to include sources of water-supply within fifty miles of the city. Ohio began such work in 1897; Illinois has been engaged on a chemical survey for a number of years; and considerable work has been done by the cities of Chicago and St. Louis. Other states have also made examinations, and in many cases have established a standard of purity for the state. All water intended for municipal use must conform to this standard. Michigan and Iowa are examples.

Since geological conditions vary, it is necessary for each state to deal with its own problems, and sometimes, as in Kansas, the problem must be worked out for different sections of the state. The chlorine standard for the watersheds of southeasterm Kansas will not answer for the valley of the Kansas river.

As I have said before, the control of the water-supply should be in the hands of the state, and since Massachusetts has done the most work and the best work in solving the problens discussed, I will quote the law passed in that state in 1888, entitled

AN ACT to protect the purity of inland waters, and to require consultation with the State Board of Health regarding the establishment of systems of water-supply, drainage, and sewerage.

SECTION 1. The State Board of Health shall have the general oversight and care of all inland waters, and shall be furnished with maps, plans and documents suitable for this purpose, and records of all its doings in relation thereto shall be kept. It may employ such engineers and clerks and other assistants as it may deem necessary; provided, that no contracts or other acts which involve the payment of money from the treasury of the commonwealth shall be made or done without an appropriation expressly made therefor by the general court. It shall annually, on or before the 10th day of January, report to the general court its doings in the preceding year, and at the same time submit estimates of the sums required to meet the expenses of said board in relation to the care and oversight of inland waters for the ensuing year, and it shall also recommend legislation and suitable plans for such systems of main sewers as it may deem necessary for the preservation of the public health, and for the purification and prevention of pollution of the ponds, streams and inland waters of the commonwealth.

SEC. 2. Said board shall, from time to time, as it may deem expedient, cause examinations of the said waters to be made for the purpose of ascertaining whether the same are adapted for use as sources of domestic water-supplies or are in a condition likely to impair the interests of the public or persons lawfully using the same or imperil the public health. It shall recommend measures for prevention of the pollution of such waters and for removal of substances and causes of every kind which may be liable to cause pollution thereof, in order to protect and develop the rights and property of the commonwealth therein and to protect the public health. It shall have authority to conduct experiments to determine the best practicable methods of purification of drainage and sewage or disposal of the same. For the purpose aforesaid, it may employ such expert assistance as may be necessary.

SEC. 3. It shall from time to time consult with and advise the authorities of

cities and towns, or with corporations, firms or individuals either already having or intending to introduce systems of water-supply, drainage, or sewerage, as to the most appropriate source of supply, the best practicable method of assuring the purity thereof or of disposing of their drainage or sewage, having regard to the present and prospective needs and interests of other cities, towns, corporations, firms or individuals which may be affected thereby. It shall also from time to time consult with and advise persons or corporations engaged or intending to engage in any manufacturing or other business, drainage or sewage from which may tend to cause the pollution of any inland water, as to the best practicable method of preventing such pollution by the interception, disposal or purification of such drainage or sewage; provided, that no person shall be compelled to bear the expense of such consultation or advice, or of experiments made for the purpose of this act. All such authorities, corporations, firms and individuals are hereby required to give notice to said board of their intentions in the premises, and to submit for its advice outlines of their proposed plans or schemes in relation to water-supply and disposal of drainage and sewage; and all petitions to the legislature for authority to introduce a system of water-supply, drainage or sewage shall be accompanied by a copy of the recommendation and advice of the said board thereon. Such board shall bring to the notice of the attorney-general all instances which may come to its knowledge of omission to comply with existing laws respecting the pollution of water-supplies and inland waters, and shall annually report to the legislature any specific cases not covered by the provisions of existing laws which, in its opinion, call for further legislation.

SEC. 4. In this act the term "drainage" refers to rainfall, surface- and subsoil-water only, and "sewage" refers to domestic and manufacturing filth and refuse.

SEC. 5. Chapter 274 of the acts of the year 1886 is hereby repealed, but nothing in this act shall be construed to affect the expenditures authorized under chapter 30 of the resolves of the year 1888.

SEC. 6. This act shall take effect upon its passage. (Approved May 18, 1888.)

A similar law is entirely possible in Kansas. The water-supply from the rivers of Kansas can be rendered perfectly hygienic. It is my hope that the legislature will direct the State Board of Health to—

I. Have a general oversight of the water-supplies and sewage systems of the state;

II. Employ engineers, chemists and whatever expert assistance may be necessary to make a chemical examination of the water-supplies, who shall experiment as is necessary with sewage purification, who shall establish a standard of purity for the water to be served to cities and towns, and who shall advise cities and towns in regard to the care of supplies already in use, and to assist them in planning further supplies.